Thin Film Resistor Fabrication for InP Technology Applications

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In this study we evaluated both NiCr and TaN thin-film resistor material for use with our InP technology. Thermal stability, sensitivity to oxidation, temperature coefficients, and patterning techniques were compared for the two materials. Both of these resistor materials are suitable for integration into our InP technology.

The film stiochiometry was obtained using RBS. E-beam evaporation of NiCr (80:20) resulted in films that were rich in Cr (38%), due to a higher vapor pressure of Cr. Thus it was preferentially evaporated from the (80:20) source. The TaN, deposited by sputter deposition, by on the other hand, was stiochiometric to within a few atomic %.

Table I shows the Rs stability after several treatments. The NiCr showed a 5% increase in Rs when exposed to O_2 plasma, and was stable for anneal temperatures of up to 300°C. Alternatively, the TaN was stable for O_2 plasma exposure, but had an increase in Rs of 5% or 10% when annealed at 300°C in N_2 or air ambients, respectively. From a fabrication point of view, the NiCr was more stable during bake cycles. However, it must be encapsulated to protect it from O_2 plasma exposure. It can, therefore be used earlier on in the process. On the other hand TaN was more stable during plasma exposure, however, it must not be baked at high temperatures. It can thus be used at the back-end of the process.

Table I. Rs (Ω/☐) after several treatments.

Substrate	Film	NT	O_2	300°C/air	300°C/N_2
InP	NiCr	48.6	51.0	48.2	47.8
% Δ			+ 4.94	- 0.82	- 1.44
SiN/Si	NiCr	51.0	52.8	51.5	50.4
% Δ		+ 4.94	+ 3.53	+ 0.98	- 1.18
InP	TaN	49.4	49.2	53.3	51.2
% Δ			- 0.40	+ 7.89	+ 3.64
SiN/Si	TaN	51.0	51.5	56.0	48.2
% Δ		+ 3.24	+ 0.98	+ 9.80	+ 5.49

The run-to-run reproducibility is shown in Figures 1 (a) and (b) for the NiCr and TaN, respectively. The target Rs was 50Ω/☐. The thickness required for the NiCr was 250Å ± 10Å; the TaN was 802Å ± 2Å. The Rs reproducibility improved from 5% to less than 1% variation after the installation of an in-situ monitor in the evaporator. The TaN run-to-run variation was less than 1% with no in-situ monitoring. Interestingly, the NiCr thickness required to obtain an Rs of 50Ω/☐ was around 250Å, as opposed to 800Å for the TaN. Thus, the TaN material may be more reliable for higher current density applications. In addition, the TaN would be better in applications where resistors with higher Rs, such as 200Ω/☐, are required

Finally, Figures 2 (a) and (b) show Rs and Rc as a function of temperature, respectively. The room temperature Rs was 53.7Ω/☐, and Rc was 1.1×10^{-9}Ωcm^2. From the slope of the line, the NiCr has a TCR of around 60ppm and 200ppm for Rs and Rc, respectively. Unfortunately, The TaN could not be determined, since access to the machine has been discontinued.

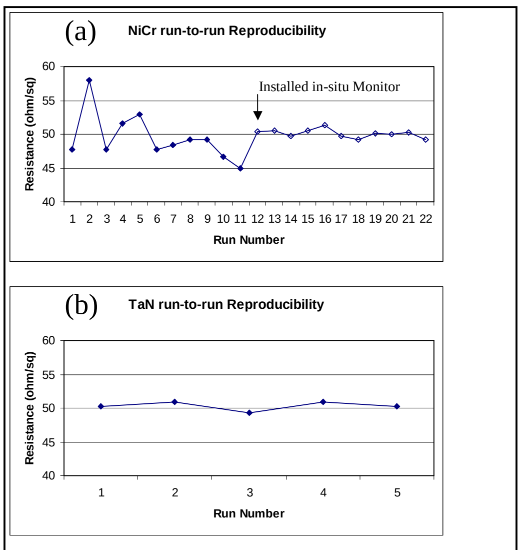

Figure 1. Run-to-run sheet resistance reproducibility.

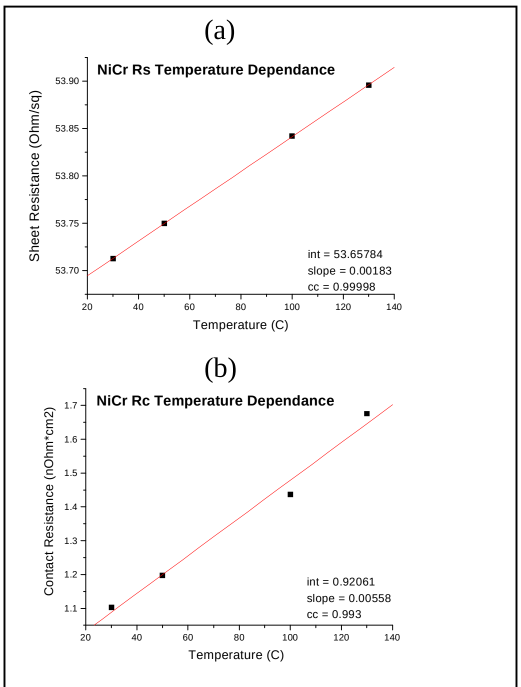

Figure 2. Temperature dependence of NiCr resistors.